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14. ABSTRACT					
15. SUBJECT TERMS					
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a. REPORT UU	b. ABSTRACT UU	c. THIS PAGE UU			19b. TELEPHONE NUMBER 607-255-1210

RPPR Final Report
as of 31-Dec-2018

Agency Code:

Proposal Number: 61783MAMUR
INVESTIGATOR(S):

Agreement Number: W911NF-12-1-0385

Name: Ph.D Gennady Samorodnitsky
Email: gs18@cornell.edu
Phone Number: 6072559141
Principal: N

Name: Lang Tong
Email: lt35@cornell.edu
Phone Number: 6072553900
Principal: N

Name: Sidney Ira Resnick
Email: resnick@cornell.edu
Phone Number: 60725512100000
Principal: Y

Organization: **Cornell University**

Address: Office of Sponsored Programs, Ithaca, NY 148502820
Country: USA

DUNS Number: 872612445

EIN: 150532082

Report Date: 31-Dec-2018

Date Received: 26-Dec-2018

Final Report for Period Beginning 16-Aug-2012 and Ending 30-Sep-2018

Title: Multivariate Heavy Tail Phenomena: Modeling and Diagnostics

Begin Performance Period: 16-Aug-2012

End Performance Period: 30-Sep-2018

Report Term: 0-Other

Submitted By: Sidney Resnick

Email: resnick@cornell.edu

Phone: (607) 255-12100000

Distribution Statement: 1-Approved for public release; distribution is unlimited.

STEM Degrees: 44

STEM Participants: 1

Major Goals: This project develops reliable diagnostic, inferential and model validation tools for heavy tailed multivariate data; generates new classes of multivariate heavy tailed models that highlight the implications of dependence and tail weight; and applies these statistical and mathematical developments to the key application areas of network design and control, social network analysis, and cloud computing. Our application interests also include network security, anomaly detection, mobile application scheduling and risk analysis.

To understand and exploit multivariate heavy tail phenomena in relevant application areas, our project contributes statistical, mathematical and software tools that provide:

- (a) Flexible and practical representations of multidimensional heavy tail distributions that permit reliable statistical analysis and inference; allow model discovery, selection and confirmation; quantify dependence; and overcome the curse of dimensionality.
- (b) Heavy tailed mathematical models that can be calibrated; which clearly exhibit the influence of dependence and tail weight; and which are appropriate to the applied context.
- (c) Exploitation of the new tools of multivariate heavy tail analysis to study social networks; mobile networks; network design and control; application scheduling in mobile devices and cloud computing; and robust network search.

Accomplishments: See pdf document in "Upload" section.

RPPR Final Report

as of 31-Dec-2018

Training Opportunities: Training opportunities, for the most part, have been addressed through working with PhD students and occasionally undergraduates. There have been Post-Docs supported on the MURI at Columbia and Ohio State as well as unsupported post-docs who have been mentored by MURI PI's; eg. Jaakko Lehtomaa mentored by Sidney Resnick at Cornell.

Seminars, short courses, conference lectures and papers by MURI PI's all serve to educate the professional public about our work. This is all detailed in our annual progress reports.

Results Dissemination: Reports and talks are publicly posted at

<https://www.orie.cornell.edu/research/research-groups/multivariate-heavy-tail-phenomena-modeling-and-diagnostics>

and there are also links to software that has been developed through the 5 years; this has been reported in the yearly progress reports. Each of the PI's maintained an active speaking schedule at seminars, workshops and conferences as well as active publication activities.

Results are also reported at conferences and workshops and submitted to leading journals. This has been archived in yearly progress reports as well.

Samorodnitsky published a book about a year ago on related topics. Nolan is about 80% done with volume 1 about multivariate stable laws.

RPPR Final Report as of 31-Dec-2018

Honors and Awards: Richard Davis was elected to the council of the Institute of Mathematical Statistics 2013. Richard Davis was selected to deliver the 2014 Hotelling Lectures at the University of North Carolina. Zhi-Li Zhang was awarded the McKnight Distinguished University Professor by the University of Minnesota 2013, Board of Regents in 2013.

R. Srikant gave the Keynote Lecture at ACM MobiHoc 2013.

R. Srikant was chosen to be the Editor-in-Chief of the IEEE/ACM Transactions on Networking, starting from July 2013.

D. Towsley gave a Keynote Lecture at IFIP Networking 2013.

D. Towsley won best paper awards at IEEE ICDCS 2013 and IEEE VTC- Spring '13.

L. Tong is selected to give a plenary lecture at 2013 IEEE Global Conference on Signal and Information Processing.

L. Tong is selected to give a plenary lecture at The Fifth IEEE International Workshop on Computational Advances in Multi-Sensor Adaptive Processing.

R Davis 2014: Elected President-elect of Institute of Mathematical Statistics (IMS, <http://imstat.org/en/index.html>): (president-elect, president, past-president, 2014-2017) Hotelling Lectures, March 24-26, 2014, University of North Carolina, Chapel Hill (<http://stator.unc.edu/colloquia/Hotelling>).

Van Dantzig Seminar, Jan 23, 2014, University of Delft, The Netherlands (<http://www.few.vu.nl/~bkk320/vandantzig/>).

Scientific Organizing Committee: "International Conference Ars Conjectandi 1713-2013 Conference" in celebration of the 300th anniversary of the publication of Jacob Bernoulli's "Ars conjectandi", Basel, Switzerland. October 16-18, 2013.

Scientific Advisory Committee: "Inference for Change-Point and Related Processes," Isaac Newton Institute for Mathematical Sciences, Cambridge, UK. Jan 13-Feb 7 2014.

Scientific Organizing Committee, Extreme Value Analysis, Ann Arbor, MI, June 27–July 1, 2015. Plenary Speaker, Graybill Conference, Ft. Collins, CO. June 14-17, 2015.

Shroff 2014: received the IEEE INFOCOM achievement award for "seminal contributions to scheduling and resource allocation in wireless networks".

-listed on Most highly cited researchers Thomson Reuters ISI (<http://highlycited.com/>), ranking among the top 1% most cited for their subject field.

-noted in the List of The World's Most Influential Scientific Minds in 2014. (<http://sciencewatch.com/sites/sw/files/sw-article/media/worlds-most-influential-scientific-minds-2014.pdf>).

Towsley 2014 Distinguished Lectures related to project (Towsley):

Kelly Distinguished Lecture,

--Pennsylvania State University (October 2013)

--University of North Carolina – Charlotte (April 2014)

Shroff was recently listed on Most highly cited researchers Thomson Reuters ISI ranking among the top 1% most cited for their subject field.

Shroff is noted in the List of The World's Most Influential Scientific Minds in 2014.

Davis: Elected President of Institute of Mathematical Statistics (IMS, <http://imstat.org/en/index.html>): (president-elect, president, past-president, 2014-2017)

Davis: Scientific Organizing Committee: "International Conference Ars Conjectandi 1713-2013 Conference" in celebration of the 300th anniversary of the publication of Jacob Bernoulli's "Ars conjectandi", Basel, Switzerland. October 16-18, 2013.

Davis: Scientific Organizing Committee, Extreme Value Analysis, Ann Arbor, MI, June 27–July 1, 2015.

Davis: Plenary Speaker, Graybill Conference, Ft. Collins, CO. June 14-17, 2015.

Davis: Plenary Speaker, 2015 Fifth International IMS-FIPS Workshop, Rutgers. Jun 25–27, 2015.

Davis: Organizer of Invited IMS Session for JSM, Seattle, WA. Aug 8–13, 2015.

Davis: Co-organizer (with Thomas Mikosch, Paul Embrechts, and Andrew Patton) "The Mathematics and Statistics of Quantitative Risk Management," Oberwolfach, Germany, Sept 20–25, 2015.

Davis: Organizing Committee "Indo-US Workshop on Time Series Analysis", sponsored by SAMSI and Indian Institute of Science Education and Research, IISER, Pune, India, May 25-30, 2015.

Davis: International Advisory Committee "Celebrating Statistical Innovation and Impact in a World of Big and Small Data." Sponsored by IISA and the University of Pune, Dec 20-24, 2015.

Davis: Scientific Committee "Second International Congress in Actuarial Science and Quantitative Finance", Cartagena, Colombia, June 15-18, 2016.

Gong/Towsley: Distinguished Lecture, BBN April 2015 "Sampling Node Pairs in Large Graphs"

Zhang: Best Paper Award, SIMPLEX'15

Srikant: IEEE INFOCOM Achievement Award, 2015

Srikant: IEEE INFOCOM Best Paper Award, 2015

Srikant: IIT Madras Distinguished Alumnus Award, 2015

RPPR Final Report as of 31-Dec-2018

Towsley: BBN April 2015 “Sampling Node Pairs in Large Graphs

Gong: Univ Distinguished Professor of UofMass - Oct 2016

Towsley: Elected corresponding member of Brazilian Academy of Science 2016

Towsley: 2016 ACM SIGMETRICS/IFIP Performance of best paper award.

Shroff: 1. Best paper award at IEEE INFOCOM 2016 (J. Liu, A. Eryilmaz, N. B. Shroff, and E. Bentley, “Heavy-Ball: A New Approach to Tame Delay and Convergence in Wireless Network Optimization,” IEEE INFOCOM’16, San Francisco, CA, Apr. 2016).

Shroff: IEEE Communications Society William R. Bennett Prize 2016 (postdoc Joohyun Lee)

Davis: President, Institute of Mathematical Statistics 2016

Ness B. Shroff

Best student paper award at ACM Sigmetrics 2017 (Sinong Wang, and Ness B. Shroff), Urbana-Champaign, IL, Jun. 2017.

Richard A. Davis, Columbia University: Session organizer (with Arup Bose), “Random Matrices” for the Symposium on Probability and Theory and

Stochastic Processes, sponsored by the Indian Mathematics Consortium in co-operation with the American Mathematics Society. Banaras Hindu University, Varanasi, India. Dec 14-17, 2016.

Richard A. Davis Conference Organizer and Host (with Serena Ng): 2016 NBER/NSF Workshop on Time Series Analysis, Columbia University, Collins, CO, Sept 16–Sept 17, 2016.

Richard A. Davis Session organizer (with Phyllis Wan), “Extreme Value Analysis” for New England Statistics Symposium, Storrs, April 22, 2017.

Richard A. Davis Conference Organizer and Host (with Serena Ng): 2016 NBER/NSF Workshop on Time Series Analysis,

Columbia University, Sept 16–Sept 17, 2016.

Zhang: Yang Zhang, Eman Ramadan, Hesham Mekky and Zhi-Li Zhang. “When Raft Meets SDN: How to Elect a Leader and Reach Consensus in an Unruly Network”, ACM APNET’17 Best Paper Award

Srikant: Plenary Speaker, 2017 Applied Probability Society Conference

Phyllis Wan, JSM Student Travel Award presented by Section on Business and Economic Statistics. JSM 2017 Elected Fellow of International Engineering and Technology Institute, 2018

Chosen as Jubilee Professor, Department of Mathematical Sciences, Chalmers University of Technology, Göteborg, Sweden. (Position takes place in 2019.)

Co-organizer (with John Aston and Axel Munk) of Second workshop in the Programme “Statistical Scalability” (Issac Newton Institute Workshop), “Statistics of geometric features and new data types”, Cambridge University, March 19-23, 2018.

Scientific Committee “Third International Congress in Actuarial Science and Quantitative Finance”, Manizales, Colombia, June 19-22, 2019

Scientific Committee for the Extreme Value Analysis 2019 Meeting, Zagreb, July 1-5, 2019.

Conference Organizer (with Serena Ng and Ruey Tsay): NBER/NSF Workshop on Time Series Analysis, Northwestern University, Sept 8–9, 2017.

Protocol Activity Status:

Technology Transfer: Ness Shroff was one of 3 authors for patent application T2016-095, 62/281,244 entitled “A highly energy-efficient context-aware scheduler on background applications in mobile systems”.

Public domain information about papers, talks and software is at our MURI website

<https://www.orie.cornell.edu/orie/research/research-groups>

which contains a fairly complete record of the intellectual output from the group.

PARTICIPANTS:

Participant Type: Faculty

Participant: Richard Davis

Person Months Worked: 4.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

RPPR Final Report
as of 31-Dec-2018

Participant Type: Faculty
Participant: Weibo Gong
Person Months Worked: 5.00
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Funding Support:

Participant Type: Faculty
Participant: John Nolan
Person Months Worked: 12.00
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Funding Support:

Participant Type: Faculty
Participant: Sidney Resnick
Person Months Worked: 8.00
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Funding Support:

Participant Type: Faculty
Participant: Gennady Samorodnitsky
Person Months Worked: 6.00
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Funding Support:

Participant Type: Faculty
Participant: Ness Shroff
Person Months Worked: 2.00
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Funding Support:

Participant Type: Faculty
Participant: R. Srikant
Person Months Worked: 2.00
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Funding Support:

RPPR Final Report
as of 31-Dec-2018

Participant Type: Faculty
Participant: Don Towsley
Person Months Worked: 3.00
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Funding Support:

Participant Type: Faculty
Participant: Zhi-Li Zhang
Person Months Worked: 7.00
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Funding Support:

Participant Type: Faculty
Participant: Lang Tong
Person Months Worked: 1.00
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Funding Support:

Participant Type: Postdoctoral (scholar, fellow or other postdoctoral position)
Participant: Yoora Kim
Person Months Worked: 1.00
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Funding Support:

Participant Type: Graduate Student (research assistant)
Participant: Siva Theja Maguluri
Person Months Worked: 8.00
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Funding Support:

Participant Type: Graduate Student (research assistant)
Participant: Gyan Ranjan
Person Months Worked: 4.00
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N

Funding Support:

RPPR Final Report
as of 31-Dec-2018

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Golshan Golnari

Person Months Worked: 9.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Yanhua Li

Person Months Worked: 1.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Tilo Nguyen

Person Months Worked: 6.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Takashi Owada

Person Months Worked: 12.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Yi Shen

Person Months Worked: 12.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Joyjit Roy

Person Months Worked: 9.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

RPPR Final Report
as of 31-Dec-2018

National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Irem Koprulu

Person Months Worked: 6.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Swapna Buccapatnam

Person Months Worked: 6.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Zhu Yu

Person Months Worked: 6.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Shiyao Chen

Person Months Worked: 6.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: James Atwood

Person Months Worked: 3.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Zizhan Zheng

Person Months Worked: 2.00

Funding Support:

Project Contribution:

International Collaboration:

RPPR Final Report
as of 31-Dec-2018

International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Saurabh Verma
Person Months Worked: 9.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Saurabh Verma
Person Months Worked: 9.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Braulio Dumba
Person Months Worked: 5.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Bo Jiang
Person Months Worked: 5.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Chan Lu
Person Months Worked: 10.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Julian Sun
Person Months Worked: 7.00 **Funding Support:**
Project Contribution:

RPPR Final Report
as of 31-Dec-2018

International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Amy Willis

Person Months Worked: 4.00

Funding Support:

Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Phyllis Wan

Person Months Worked: 3.00

Funding Support:

Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Jieqi Kang

Person Months Worked: 5.00

Funding Support:

Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Fabricio Ferreira

Person Months Worked: 1.00

Funding Support:

Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Kun Tu

Person Months Worked: 2.00

Funding Support:

Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Tiandong Wang

Person Months Worked: 7.00

Funding Support:

RPPR Final Report
as of 31-Dec-2018

Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: F. Tang

Person Months Worked: 5.00

Funding Support:

Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Postdoctoral (scholar, fellow or other postdoctoral position)

Participant: Jingjing Zou

Person Months Worked: 11.00

Funding Support:

Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Emily Fisher

Person Months Worked: 11.00

Funding Support:

Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Pakawat Phalitnonkiat

Person Months Worked: 1.00

Funding Support:

Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Tiandong Wang

Person Months Worked: 10.00

Funding Support:

Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Fabricio Murai

RPPR Final Report
as of 31-Dec-2018

Person Months Worked: 8.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Zhenzhi Qian

Person Months Worked: 3.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Morteza Hashemi

Person Months Worked: 9.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Joohyun Lee

Person Months Worked: 3.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Saurabh Verma

Person Months Worked: 8.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Undergraduate Student

Participant: Peter Kneller

Person Months Worked: 1.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

RPPR Final Report
as of 31-Dec-2018

Participant: Siddhartha Satpathi

Person Months Worked: 3.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Bin Li

Person Months Worked: 3.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Ahmed Bedewy

Person Months Worked: 5.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Kate Jensen

Person Months Worked: 6.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Arman Kabir

Person Months Worked: 8.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Joseph Lubars

Person Months Worked: 3.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

RPPR Final Report
as of 31-Dec-2018

Participant Type: Graduate Student (research assistant)

Participant: Yuelin Sun

Person Months Worked: 11.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Xiaoyang Liu

Person Months Worked: 2.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Lifan Wu

Person Months Worked: 2.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)

Participant: Xiaoli Chen

Person Months Worked: 2.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

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Journal: Astin Bulletin

Publication Identifier Type:

Publication Identifier:

Volume: 43

Issue: 2

First Page #: 245

Date Submitted:

Date Published:

Publication Location:

Article Title: Multivariate tail measure and the estimation of CoVar

Authors:

Keywords: extremes, tail estimation, tail measure, spectral measure, CoVar, tail region

Abstract: The quality of estimation of multivariate tails depends significantly on the portion of the sample included in the estimation. A simple approach involving sequential statistical testing is proposed in order to select which observations should be used for estimation of the tail and spectral measures. We prove that the estimator is consistent. We test the proposed method on simulated data, and subsequently apply it to analyze CoVar for stock and index returns.

Distribution Statement: 1-Approved for public release; distribution is unlimited.

Acknowledged Federal Support:

RPPR Final Report

as of 31-Dec-2018

Publication Type: Journal Article Peer Reviewed: Y **Publication Status:** 1-Published

Journal: Wiley Interdisciplinary Reviews: Computational Statistics

Publication Identifier Type: DOI

Publication Identifier: 10.1002/wics.1286

Volume: 6

Issue: 1

First Page #: 45

Date Submitted:

Date Published:

Publication Location:

Article Title: Financial modeling with heavy-tailed stable distributions

Authors:

Keywords: Multivariate stable, heavy tailed distributions, elliptical contours

Abstract: Stable distributions with elliptical contours are a class of distributions that are useful for modeling heavy tailed multivariate data. This paper describes the theory of such distributions, presents formulas for calculating their densities, and methods for fitting the data and assessing the fit. Efficient numerical routines are implemented and evaluated in simulations. Applications to data sets of a financial portfolio with 30 assets and to a bivariate radar clutter data set are presented.

Distribution Statement: 1-Approved for public release; distribution is unlimited.

Acknowledged Federal Support:

Publication Type: Journal Article Peer Reviewed: Y **Publication Status:** 1-Published

Journal: ACM Mobihoc 2014

Publication Identifier Type: DOI

Publication Identifier: 10.1145/2632951.2632991

Volume: 0

Issue: 0

First Page #: 0

Date Submitted:

Date Published:

Publication Location:

Article Title: An analytical framework to characterize the efficiency and delay in a mobile data offloading system

Authors:

Keywords: Multivariate heavy tails, data offloading, mobile wireless networks

Abstract: Smart mobile devices are generating a tremendous amount of data traffic that is putting stress on even the most advanced cellular networks. Delayed offloading has recently been proposed as an efficient mechanism to substantially alleviate this stress. The idea is simple. It allows a mobile device to delay transmission of data packets for a certain amount of time, while it searches WiFi (or similarly femtocell) networks to offload the data during the time. When the time expires, it completes the remaining portion of the delayed transmission through the cellular network that is available at the moment. In this paper, we develop an analytical framework using an embedded Markov process for the delayed offloading system. We provide a closed-form expression for estimating how much data generated by the users can be offloaded to WiFi networks from cellular networks even when there are non-Markovian data arrivals and service interruptions. We conduct extensive numerical studies with various ra

Distribution Statement: 1-Approved for public release; distribution is unlimited.

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RPPR Final Report as of 31-Dec-2018

Publication Type: Journal Article Peer Reviewed: Y **Publication Status:** 1-Published

Journal: ACM SIGMETRICS Performance Evaluation Review

Publication Identifier Type: DOI

Publication Identifier: 10.1145/2591971.2591989

Volume: 0

Issue: 0

First Page #: 0

Date Submitted:

Date Published:

Publication Location:

Article Title: Stochastic bandits with side observations on networks

Authors:

Keywords: Multi-arm bandits, stochastic analysis, social networks.

Abstract: We study the stochastic multi-armed bandit (MAB) problem in the presence of side-observations across actions. In our model, choosing an action provides additional side observations for a subset of the remaining actions. One example of this model occurs in the problem of targeting users in online social networks where users respond to their friends's activity, thus providing information about each other's preferences. Our contributions are as follows: 1) We derive an asymptotic (with respect to time) lower bound (as a function of the network structure) on the regret (loss) of any uniformly good policy that achieves the maximum long term average reward. 2) We propose two policies - a randomized policy and a policy based on the well-known upper confidence bound (UCB) policies, both of which explore each action at a rate that is a function of its network position. We show that these policies achieve the asymptotic lower bound on the regret up to a multiplicative factor independent of network.

Distribution Statement: 1-Approved for public release; distribution is unlimited.

Acknowledged Federal Support:

Publication Type: Journal Article Peer Reviewed: Y **Publication Status:** 1-Published

Journal: IEEE/ACM Transactions on Networking

Publication Identifier Type: DOI

Publication Identifier: 10.1109/TNET.2013.2288973

Volume: 0

Issue: 0

First Page #: 0

Date Submitted:

Date Published:

Publication Location:

Article Title: Scheduling Jobs With Unknown Duration in Clouds

Authors:

Keywords: Cloud computing, performance evaluation, queueing theory, resource allocation, scheduling.

Abstract: We consider a stochastic model of jobs arriving at a cloud data center. Each job requests a certain amount of CPU, memory, disk space, etc. Job sizes (durations) are also modeled as random variables, with possibly unbounded support. These jobs need to be scheduled nonpreemptively on servers. The jobs are first routed to one of the servers when they arrive and are queued at the servers. Each server then chooses a set of jobs from its queues so that it has enough resources to serve all of them simultaneously. This problem has been studied previously under the assumption that job sizes are known and upper-bounded, and an algorithm was proposed that stabilizes traffic load in a diminished capacity region. Here, we present a load balancing and scheduling algorithm that is throughput-optimal, without assuming that job sizes are known or are upper-bounded.

Distribution Statement: 1-Approved for public release; distribution is unlimited.

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Publication Type: Journal Article Peer Reviewed: Y **Publication Status:** 1-Published

Journal: Stochastic Processes and their Applications

Publication Identifier Type: DOI

Publication Identifier: 10.1016/j.spa.2013.03.014

Volume: 123

Issue: 7

First Page #: 2575

Date Submitted:

Date Published:

Publication Location:

Article Title: Measures of serial extremal dependence and their estimation

Authors:

Keywords: Extremogram; Extremal index; Regular variation; Max-stable process; Periodogram

Abstract: The goal of this paper is two-fold: (1) We review classical and recent measures of serial extremal dependence in a strictly stationary time series as well as their estimation. (2) We discuss recent concepts of heavy-tailed time series, including regular variation and max-stable processes. Serial extremal dependence is typically characterized by clusters of exceedances of high thresholds in the series. We start by discussing the notion of extremal index of a univariate sequence, i.e. the reciprocal of the expected cluster size, which has attracted major attention in the extremal value literature. Then we continue by introducing the extremogram which is an asymptotic autocorrelation function for sequences of extremal events in a time series. In this context, we discuss regular variation of a time series. This notion has been useful for describing serial extremal dependence and heavy tails in a strictly stationary sequence. We briefly discuss the tail process coined by Basrak and Segers.

Distribution Statement: 1-Approved for public release; distribution is unlimited.

Acknowledged Federal Support:

BOOKS:

Publication Type: Book Peer Reviewed: Y **Publication Status:** 1-Published

Publication Identifier Type:

Publication Identifier:

Book Edition:

Volume:

Publication Year: 2016

Date Received: 30-Aug-2017

Publication Location: New York

Publisher: Springer

Book Title: Stable Distributions: Models for Heavy-Tailed Data

Authors: John P. Nolan

Editor:

Acknowledged Federal Support: Y

CONFERENCE PAPERS:

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published

Conference Name: IEEE INFOCOM 2013

Date Received: 26-Dec-2018

Conference Date: 15-Apr-2013

Date Published: 25-Jul-2013

Conference Location: Turin, Italy

Paper Title: Exploiting Double Opportunities for DeadlineBased Content Propagation in Wireless Networks

Authors: Han Cai, Irem Koprulu, Ness B. Shroff

Acknowledged Federal Support: Y

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published

Conference Name: 52nd IEEE Conference on Decision and Control, December 2013., Florence, Italy

Date Received: 26-Dec-2018

Conference Date: 12-Dec-2013

Date Published: 10-Mar-2014

Conference Location: Florence, Italy

Paper Title: "Transient Response Functions for Complex Graph Similarity Testing"

Authors: Weibo Gong

Acknowledged Federal Support: N

RPPR Final Report as of 31-Dec-2018

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: Proceedings of the International Teletraffic Congress (ITC),
Date Received: 26-Dec-2018 Conference Date: 04-Sep-2012 Date Published:
Conference Location: Krakow, Poland
Paper Title: Heavy traffic optimal resource allocation algorithms for cloud computing clusters.
Authors: Siva Theja Maguluri, R. Srikant, Lei Ying
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: the First Workshop
Date Received: 30-Aug-2017 Conference Date: 30-Jun-2016 Date Published:
Conference Location: Singapore, Singapore
Paper Title: Mining Spatial-Temporal
Authors: Arvind Narayanan, Saurabh Verma, Zhi-Li Zhang
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: IEEE INFOCOM 2016 - IEEE Conference on Computer Communications
Date Received: 30-Aug-2017 Conference Date: 10-Apr-2016 Date Published:
Conference Location: San Francisco, CA, USA
Paper Title: Understanding security group usage in a public IaaS cloud
Authors: Cheng Jin, Abhinav Srivastava, Zhi-Li Zhang
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: IEEE INFOCOM 2016 - IEEE Conference on Computer Communications
Date Received: 30-Aug-2017 Conference Date: 10-Apr-2016 Date Published:
Conference Location: San Francisco, CA, USA
Paper Title: SAMPO: Online subflow association for multipath TCP with partial flow records
Authors: Yang Zhang, Hesham Mekky, Zhi-Li Zhang, Fang Hao, Sarit Mukherjee and T V Lakshman
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 3-Accepted
Conference Name: 2015 ACM Information Centric Network Conference
Date Received: 30-Aug-2017 Conference Date: 31-Aug-2016 Date Published: 25-Aug-2016
Conference Location: San Francisco
Paper Title: On the Analysis of Caches with Pending Interest Tables
Authors: Mostafa Dehghan, Bo Jiang, Ali Dabirmoghaddam, Don Towsley
Acknowledged Federal Support: **N**

Publication Type: Conference Paper or Presentation **Publication Status:** 3-Accepted
Conference Name: 2016 ACM SIGMETRICS/IFIP Performance Conference
Date Received: 30-Aug-2017 Conference Date: 25-Aug-2016 Date Published: 25-Aug-2016
Conference Location: France
Paper Title: On the Duration and Intensity of Competitions in Nonlinear Pólya Urn Processes with Fitness
Authors: Bo Jiang, Daniel Figueiredo, Bruno Ribeiro, Don Towsley
Acknowledged Federal Support: **N**

RPPR Final Report
as of 31-Dec-2018

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: The 2016 International Conference on Image Processing
Date Received: 30-Aug-2017 Conference Date: 23-Sep-2016 Date Published: 25-Aug-2016
Conference Location: Phoenix Arizona
Paper Title: IMAGE FEATURE EXTRACTION BASED ON SPECTRAL GRAPH INFORMATION
Authors: Jieqi Kang, Shan Lu, Weibo Gong, Patrick A. Kelly
Acknowledged Federal Support: **N**

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: 2016 American Control Conference (ACC)
Date Received: 30-Aug-2017 Conference Date: 06-Jun-2016 Date Published: 25-Aug-2016
Conference Location: Boston, MA
Paper Title: Poisson Process Driven Stochastic Differential Equations for Bivariate Heavy Tailed Distributions
Authors: Shan Lu, Gennady Samorodnitsky, Weibo Gong, Bo Jiang, Jieqi Kang, Don Towsley
Acknowledged Federal Support: **N**

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: New England Statistical Symposium
Date Received: 30-Aug-2017 Conference Date: 22-Apr-2017 Date Published: 25-Aug-2016
Conference Location: Univ of Conn
Paper Title: An R package for modeling and simulating generalized spherical and related distributions
Authors: John Nolan
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 3-Accepted
Conference Name: IEEE INFOCOM'16
Date Received: 30-Aug-2017 Conference Date: 10-Apr-2016 Date Published: 26-Aug-2016
Conference Location: San Francisco, CA
Paper Title: Heavy-Ball: A New Approach to Tame Delay and Convergence in Wireless Network Optimization
Authors: J. Liu, A. Eryilmaz, N. B. Shroff, E. Bentley
Acknowledged Federal Support: **N**

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: ACM UbiComp
Date Received: 30-Aug-2017 Conference Date: 12-Sep-2016 Date Published: 26-Aug-2016
Conference Location: Heidelberg, Germany
Paper Title: Context-aware Application Scheduling in Mobile Systems: What Will Users Do and Not Do Next
Authors: J. Lee, K. Lee, E. Jeong, J. Jo, N. B. Shroff
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 3-Accepted
Conference Name: 50th Conference on Information Sciences and Systems (CISS)
Date Received: 30-Aug-2017 Conference Date: 16-Mar-2016 Date Published: 26-Aug-2016
Conference Location: Princeton University
Paper Title: Battle of Opinions over Evolving Social Networks
Authors: I. Koprulu, Y. Kim, N. B. Shroff
Acknowledged Federal Support: **N**

RPPR Final Report as of 31-Dec-2018

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: International Conference on Applied Probability and Computational Methods in Applied Sciences
Date Received: 30-Aug-2017 Conference Date: 03-Nov-2015 Date Published: 29-Aug-2016
Conference Location: Fudan University, Shanghai
Paper Title: Time-changed extremal process as a random sup measure
Authors: Céline Lacaux, Gennady Samorodnitsky
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: 3rd conference of the International Society for Non-Parametric Statistics (ISNPS)
Date Received: 30-Aug-2017 Conference Date: 11-Jun-2016 Date Published: 29-Aug-2016
Conference Location: Avignon
Paper Title: Multivariate subexponential distributions
Authors: J. Sun, G. Samorodnitsky
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 3-Accepted
Conference Name: IEEE Conference on Decision and Control
Date Received: 30-Aug-2017 Conference Date: 13-Dec-2016 Date Published: 30-Aug-2016
Conference Location: Las Vegas
Paper Title: Optimal Distributed Scheduling of Real-Time Traffic with Hard Deadlines
Authors: N. Lu, B. Li, R. Srikant, L. Ying
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: IEEE INFOCOM
Date Received: 30-Aug-2017 Conference Date: 11-Apr-2016 Date Published: 30-Aug-2016
Conference Location: San Francisco
Paper Title: Mean-Field-Analysis of Coding versus Replication in Cloud Storage Systems
Authors: B. Li, A. Ramamoorthy, R Srikant
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 3-Accepted
Conference Name: INFOCOM2016
Date Received: 30-Aug-2017 Conference Date: 10-Apr-2016 Date Published: 30-Aug-2016
Conference Location: San Francisco
Paper Title: Understanding Security Group Usage in a Public IaaS Cloud
Authors: Cheng Jin, Abhinav Srivastava, Zhi-Li Zhang
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: Globecom16
Date Received: 30-Aug-2017 Conference Date: 05-Dec-2016 Date Published: 05-Dec-2016
Conference Location: Washington DC
Paper Title: Most Calls are Local (but Some are Regional): Dissecting Cellular Communication Patterns
Authors: Arvind Narayanan, Saurabh Verma, Zhi-Li Zhang
Acknowledged Federal Support: **Y**

RPPR Final Report
as of 31-Dec-2018

<p>Publication Type: Conference Paper or Presentation Conference Name: CASD2015 Date Received: 30-Aug-2017 Conference Date: 30-Aug-2015 Conference Location: Fairfax, VA Paper Title: Computational geometry for multivariate statistics Authors: John P Nolan Acknowledged Federal Support: Y</p>	<p>Publication Status: 0-Other Date Published: 30-Aug-2016</p>
<p>Publication Type: Conference Paper or Presentation Conference Name: CASD 2015 Date Received: 30-Aug-2017 Conference Date: 21-Oct-2015 Conference Location: George Mason University Paper Title: Computational geometry for multivariate statistics Authors: John P. Nolan Acknowledged Federal Support: Y</p>	<p>Publication Status: 3-Accepted Date Published: 30-Aug-2016</p>
<p>Publication Type: Conference Paper or Presentation Conference Name: Quantitative Risk Management Workshop Date Received: 30-Aug-2017 Conference Date: 21-Sep-2015 Conference Location: Oberwolfach, Germany Paper Title: Semi-parametric models for multivariate extreme value distributions Authors: Anne-Laure Fougères, Cecile Mercadier, John Nolan Acknowledged Federal Support: Y</p>	<p>Publication Status: 0-Other Date Published: 30-Aug-2016</p>
<p>Publication Type: Conference Paper or Presentation Conference Name: MURI Workshop Date Received: 30-Aug-2017 Conference Date: 16-Oct-2015 Conference Location: New York, NY Paper Title: Software tool for multivariate distributions Authors: John Nolan Acknowledged Federal Support: Y</p>	<p>Publication Status: 0-Other Date Published: 30-Aug-2016</p>
<p>Publication Type: Conference Paper or Presentation Conference Name: Centre International de Rencontres Mathématiques Date Received: 30-Aug-2017 Conference Date: 24-Feb-2016 Conference Location: Luminy, France Paper Title: A measure of dependence for stable distributions Authors: Ugur Tuncay Alparslan, John P. Nolan Acknowledged Federal Support: Y</p>	<p>Publication Status: 1-Published Date Published: 30-Aug-2016</p>
<p>Publication Type: Conference Paper or Presentation Conference Name: Centre International de Rencontres Mathématiques Date Received: 30-Aug-2017 Conference Date: 24-Feb-2016 Conference Location: Luminy, France Paper Title: A measure of dependence for stable distributions Authors: Ugur Tuncay Alparslan, John P. Nolan Acknowledged Federal Support: Y</p>	<p>Publication Status: 1-Published Date Published: 30-Aug-2016</p>

RPPR Final Report
as of 31-Dec-2018

Publication Type: Conference Paper or Presentation **Publication Status:** 5-Submitted
Conference Name: STOR-i Seminar
Date Received: 30-Aug-2017 Conference Date: 11-Jan-2017 Date Published:
Conference Location: University of Lancaster
Paper Title: Extreme Value Theory without the extremes: What can be done?
Authors: Jingjing Zou, Richard Davis, Gennady Samorodnitsky
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: New England Statistics Symposium
Date Received: 30-Aug-2017 Conference Date: 21-Apr-2017 Date Published:
Conference Location: University of Connecticut
Paper Title: Threshold Selection for Multivariate Heavy-Tailed Data
Authors: P. Wan, R.A. Davis
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: Singapore University of Technology and Design
Date Received: 30-Aug-2017 Conference Date: 25-Jan-2017 Date Published:
Conference Location: Singapore University
Paper Title: Multivariate Power Laws in a Preferential Attachment Network Model; Model Calibration
Authors: P. Wan, T. Wang, R. Davis, S. Resnick
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: College of Business and Economics
Date Received: 30-Aug-2017 Conference Date: 15-Feb-2017 Date Published:
Conference Location: Australian National University, Canberra
Paper Title: Multivariate Power Laws in a Preferential Attachment Network Model; Model Calibration
Authors: P. Wan, T. Wang, R. Davis, S. Resnick
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: Working Group on Risk
Date Received: 30-Aug-2017 Conference Date: 19-Apr-2017 Date Published:
Conference Location: ESSEC Business School, Paris France
Paper Title: Multivariate Power Laws with Strong Asymptotic Dependence
Authors: B. Das, S. Resnick
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: Working Group on Risk
Date Received: 30-Aug-2017 Conference Date: 19-Apr-2017 Date Published:
Conference Location: ESSEC Business School, Paris France
Paper Title: Fitting the Linear Preferential Attachment Model
Authors: P. Wan, T. Wang, R. Davis, S. Resnick
Acknowledged Federal Support: **Y**

RPPR Final Report
as of 31-Dec-2018

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: the Symposium
Date Received: 30-Aug-2017 Conference Date: 03-Apr-2017 Date Published:
Conference Location: Santa Clara, CA, USA
Paper Title: ParaBox: Exploiting Parallelism for Virtual Network Functions in Service Chaining
Authors: Yang Zhang, Bilal Anwer, Vijay Gopalakrishnan, Bo Han Joshua Reich, Aman Shaikh, Zhi-Li Zhang
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: the Symposium
Date Received: 30-Aug-2017 Conference Date: 03-Apr-2017 Date Published:
Conference Location: Santa Clara CA
Paper Title: Magneto: Unified Fine-grained Path Control in Legacy and OpenFlow Hybrid Networks
Authors: Cheng Jin, Cristian Lumezanu, Qiang Xu, Hesham Mekky, Zhi-Li Zhang, Guofei Jiang
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: the First Asia-Pacific Workshop
Date Received: 30-Aug-2017 Conference Date: 03-Aug-2017 Date Published:
Conference Location: Hong Kong, China
Paper Title: When Raft Meets SDN
Authors: Yang Zhang, Eman Ramadan, Hesham Mekky, Zhi-Li Zhang
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: 2017 IEEE Symposium on Security and Privacy (SP)
Date Received: 30-Aug-2017 Conference Date: 22-May-2017 Date Published:
Conference Location: San Jose, CA, USA
Paper Title: Multi-touch Authentication Using Hand Geometry and Behavioral Information
Authors: Yunpeng Song, Zongmin Ca, Zhi-Li Zhang
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: IEEE INFOCOM 2017
Date Received: 30-Aug-2017 Conference Date: 01-May-2017 Date Published:
Conference Location: Atlanta, GA
Paper Title: Network Function Virtualization Enablement Within SDN Data Plane
Authors: Hesham Mekky, Fang Hao, Sarit Mukherjee, T. V. Lakshman, Zhi-Li Zhang
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: In Proc. of ITC'29 conference
Date Received: 30-Aug-2018 Conference Date: 04-Sep-2016 Date Published:
Conference Location: Genoa, Italy
Paper Title: Multi-Low-Rank Approximation For Traffic Matrices
Authors: Saurabh Verma, Arvind Narayanand, Zhi-Li Zhang
Acknowledged Federal Support: **Y**

RPPR Final Report
as of 31-Dec-2018

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: Advances in Neural Information Processing Systems 29 (NIPS 2016)
Date Received: 30-Aug-2017 Conference Date: 05-Dec-2016 Date Published:
Conference Location: Spain
Paper Title: Diffusion-Convolutional Neural Networks
Authors: James Atwood, Don Towsley
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: International Conference on Image Processing (ICIP 2016)
Date Received: 30-Aug-2017 Conference Date: 25-Sep-2017 Date Published:
Conference Location: Phoenix, AZ
Paper Title: IMAGE FEATURE EXTRACTION BASED ON SPECTRAL GRAPH INFORMATION
Authors: Jieqi Kang, Shan Lu, Weibo Gong, Patrick A. Kelly
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: American Control Conference (ACC 2017)
Date Received: 30-Aug-2017 Conference Date: 24-May-2017 Date Published:
Conference Location: Seattle WA
Paper Title: On fast retrieval of relational experiences
Authors: W. Gong, Y-C. Ho
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: Ambit Fields and Related Topics
Date Received: 30-Aug-2017 Conference Date: 15-Aug-2016 Date Published:
Conference Location: Aarhus
Paper Title: CONTACT DISTRIBUTION IN A THINNED BOOLEAN MODEL WITH POWER LAW RADII
Authors: Yinghua Dong, Gennady Samorodnitsky
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 5-Submitted
Conference Name: IEEE ICIT 2017
Date Received: 31-Aug-2017 Conference Date: 22-Mar-2017 Date Published:
Conference Location: Toronto, Canada
Paper Title: iMUTE Energy-optimal Update Policy for Perishable Mobile Contents
Authors: Joohyun Lee, Fang Liu, Kyunghan Lee, N Shroff
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 3-Accepted
Conference Name: ACM SIGMETRICS'17
Date Received: 30-Aug-2017 Conference Date: 01-Jun-2017 Date Published:
Conference Location: Urbana-Champaign, IL
Paper Title: Security Game with Non-additive Utilities and Multiple Attacker Resources
Authors: S. Wang, N. B. Shroff
Acknowledged Federal Support: **Y**

RPPR Final Report
as of 31-Dec-2018

Publication Type: Conference Paper or Presentation	Publication Status: 2-Awaiting Publication
Conference Name: AAAI'17	
Date Received: 30-Aug-2017	Conference Date: 04-Feb-2017
Conference Location: San Francisco, CA	
Paper Title: Non-additive Security Games	
Authors: S. Wang, F. Liu, N. B. Shroff	
Acknowledged Federal Support: Y	

Publication Type: Conference Paper or Presentation	Publication Status: 0-Other
Conference Name: EUSIPCO 2018	
Date Received: 30-Aug-2018	Conference Date: 03-Sep-2018
Conference Location: Rome, Italy	
Paper Title: Compressive Sensing of Temporally Correlated Sources Using Isotropic Multivariate Stable Laws	
Authors: George Tzagkarakis, John P. Nolan, Panagiotis Tsakalides	
Acknowledged Federal Support: Y	

Publication Type: Conference Paper or Presentation	Publication Status: 3-Accepted
Conference Name: AAAI '18	
Date Received: 30-Aug-2018	Conference Date: 02-Feb-2018
Conference Location: New Orleans	
Paper Title: A Change-Detection based Framework for Piecewise-Stationary Multi-Armed Bandit Problem	
Authors: F. Liu, J. Lee, N.B.Shroff	
Acknowledged Federal Support: Y	

Publication Type: Conference Paper or Presentation	Publication Status: 0-Other
Conference Name: AAAI '18	
Date Received: 30-Aug-2018	Conference Date: 02-Feb-2018
Conference Location: New Orleans, LA	
Paper Title: Information Directed Sampling for Stochastic Bandits with Graph Feedback	
Authors: F. Liu, S. Baccapatnam, N.B. Shroff	
Acknowledged Federal Support: Y	

Publication Type: Conference Paper or Presentation	Publication Status: 1-Published
Conference Name: icml workshop	
Date Received: 30-Aug-2018	Conference Date: 10-Jul-2018
Conference Location: Stockholm International Fairs, Stockholm, Sweden	
Paper Title: Graph Capsule Convolutional Neural Networks	
Authors: Saurabh Verma, Zhi-Li Zhang	
Acknowledged Federal Support: Y	

Publication Type: Conference Paper or Presentation	Publication Status: 0-Other
Conference Name: websci 2018	
Date Received: 30-Aug-2018	Conference Date: 27-May-2018
Conference Location: Amsterdam	
Paper Title: Uncovering the Nucleus of Social Networks	
Authors: Braulio Dumba, Zhi-Li Zhang	
Acknowledged Federal Support: Y	

RPPR Final Report
as of 31-Dec-2018

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: the 2017 ACM
Date Received: 30-Aug-2018 Conference Date: 06-Nov-2017 Date Published:
Conference Location: Singapore, Singapore
Paper Title: From Fingerprint to Footprint
Authors: Huandong Wang, Chen Gao, Yong Li, Zhi-Li Zhang, Depeng Jin
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: SIGSPATIAL 17
Date Received: 30-Aug-2018 Conference Date: 07-Nov-2017 Date Published:
Conference Location: Redondo Beach CA
Paper Title: CityLines: Hybrid Hub-and-Spoke Urban Transit System
Authors: Guanxiong Liu, Yanhua Li, Zhi-Li Zhang, Jun Luo, Fan Zhang
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 5-Submitted
Conference Name: NIPS 2017
Date Received: 30-Aug-2018 Conference Date: 04-Dec-2017 Date Published:
Conference Location: Long Beach Convention Center, Long Beach
Paper Title: Hunt For The Unique, Stable, Sparse And Fast Feature Learning On Graphs
Authors: Saurabh Verma, Zhi-Li Zhang
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 5-Submitted
Conference Name: Workshop on Quantum Techniques in Machine Learning
Date Received: 30-Aug-2018 Conference Date: 06-Nov-2017 Date Published:
Conference Location: Verona Italy
Paper Title: Quantum Walk Inspired Neural Networks for Graph-Structured Data
Authors: Stefan Dernbach, Arman Mohseni-Kabir, Siddharth Pal, Don Towsley, Miles Gepner
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 3-Accepted
Conference Name: 2017 IEEE56 Annual Conference on Decisions and Control
Date Received: 30-Aug-2018 Conference Date: 12-Dec-2017 Date Published:
Conference Location: Melbourne Australia
Paper Title: Relation generation and fast similarity testing for unsupervised learning
Authors: Bo Jiang, Weibo Gong
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 5-Submitted
Conference Name: 2018 European Control Conference
Date Received: 30-Aug-2018 Conference Date: 12-Jun-2018 Date Published:
Conference Location: Limassol Cyprus
Paper Title: On concept abstraction algorithms
Authors: Weibo Gong
Acknowledged Federal Support: **Y**

RPPR Final Report as of 31-Dec-2018

Publication Type: Conference Paper or Presentation **Publication Status:** 4-Under Review
Conference Name: Linear Algebra and Applications 2018
Date Received: 30-Aug-2018 Conference Date: 01-Aug-2018 Date Published:
Conference Location: Rio de Janeiro
Paper Title: Markov Tensor Theory and Cascade, Reachability, and Routing in Complex Networks
Authors: Zhi-Li Zhang
Acknowledged Federal Support: Y

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: 25th ACM SIGSPATIAL (SIGSPATIAL'17)
Date Received: 30-Aug-2018 Conference Date: 07-Nov-2017 Date Published:
Conference Location: Redondo Beach, California, USA
Paper Title: CityLines: Designing Hybrid Hub-and-Spoke Transit System with Urban Big Data
Authors: Yanhua Li, Guanxiong Liu, Zhi-Li Zhang, Jun Luo, Fan Zhang
Acknowledged Federal Support: Y

Publication Type: Conference Paper or Presentation **Publication Status:** 3-Accepted
Conference Name: FERM 2018
Date Received: 30-Aug-2018 Conference Date: 13-Jun-2018 Date Published:
Conference Location: Fudan University
Paper Title: Inference on the tail process with application to financial time series modelling
Authors: Richard A. Davis, Holger Drees, Johan Segers, Michal Warchol
Acknowledged Federal Support: Y

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: Financial Econometrics Conference
Date Received: 30-Aug-2018 Conference Date: 04-May-2018 Date Published:
Conference Location: Toulouse
Paper Title: Inference on the tail process with application to financial time series modelling
Authors: Richard A Davis, Holger Drees, Johan Segers, Michal Warchol
Acknowledged Federal Support: Y

Publication Type: Conference Paper or Presentation **Publication Status:** 0-Other
Conference Name: HKUST2018
Date Received: 30-Aug-2018 Conference Date: 01-Jul-2018 Date Published:
Conference Location: Hong Kong
Paper Title: Extreme Value Analysis Without the Largest Values: What Can Be Done?
Authors: Jingjing Zou, Richard A. Davis, Gennady Samorodnitsky
Acknowledged Federal Support: Y

DISSERTATIONS:

Publication Type: Thesis or Dissertation
Institution:
Date Received: 29-Aug-2013 Completion Date:
Title: Characterizing Diverse Link Patterns in Complex Networks: Theory and Applications
Authors:
Acknowledged Federal Support:

RPPR Final Report
as of 31-Dec-2018

Publication Type: Thesis or Dissertation

Institution:

Date Received: 09-Sep-2013

Completion Date:

Title: Understanding (Inter-)Dependencies and Vulnerabilities in Static and Dynamic Networks

Authors:

Acknowledged Federal Support:

Publication Type: Thesis or Dissertation

Institution:

Date Received: 31-Aug-2015

Completion Date:

Title: Asymptotic Properties of the Empirical Spatial Extremogram

Authors:

Acknowledged Federal Support:

Publication Type: Thesis or Dissertation

Institution:

Date Received: 31-Aug-2015

Completion Date:

Title: NETWORK CHARACTERISTICS AND DYNAMICS: RECIPROCITY, COMPETITION AND INFORMATION DISSEMINATION

Authors:

Acknowledged Federal Support:

Publication Type: Thesis or Dissertation

Institution: University of Minnesota

Date Received: 31-Aug-2018

Completion Date: 3/2/18 7:19AM

Title: Towards More Manageable and Secure Enterprise and Data-Center Networks

Authors: Cheng Jin

Acknowledged Federal Support: Y

Publication Type: Thesis or Dissertation

Institution: University of Minnesota

Date Received: 30-Aug-2018

Completion Date: 7/1/18 8:00AM

Title: Analysis of the Structural Properties and Scalability of Complex Networks

Authors: Braulio Gabriel Dumba

Acknowledged Federal Support: Y

Publication Type: Thesis or Dissertation

Institution: University of Minnesota

Date Received: 31-Aug-2018

Completion Date: 12/1/17 3:00PM

Title: Markov Tensor Theory and Cascade, Reachability, and Routing in Complex Networks

Authors: Golshan Golnari

Acknowledged Federal Support: Y

Publication Type: Thesis or Dissertation

Institution: Cornell University

Date Received: 31-Aug-2018

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Title: MODELLING AND INFERENCE FOR EXTREMAL EVENTS: METHODS AND TECHNIQUES

Authors: Julian, Sun

Acknowledged Federal Support: N

RPPR Final Report
as of 31-Dec-2018

WEBSITES:

URL: <http://www.orie.cornell.edu/orie/research/groups/multheavytail/>

Date Received: 29-Aug-2017

Title: Cornell MURI website and archive

Description: Repository for talks, papers and software arising out of the Cornell MURI project.

PATENTS:

Intellectual Property Type: Patent

Date Received: **31-Aug-2018**

Patent Title: A Highly Energy-Efficient Context-Aware Scheduler on Background Applications in Mobile Systems

Patent Abstract: This is a scheduling algorithm that balances memory needs, energy conservation and app open

Patent Number: 62/281,244

Patent Country: USA

Application Date: 27-Aug-2018

Application Status: 1

Date Issued:

Accomplishments

(1) Foreword:

The organization of the research effort has been in these categories:

[A] *Core theory*, modeling, statistical methodology, numerical techniques for multivariate heavy tailed phenomena.

[B] *Applications* of heavy tailed techniques to modeling, discovery, and control of mobile and social networks; scheduling in cloud computing and wireless networks.

(2) Results

(2A) Core theory: Multivariate tail inference, risk estimation, dependence measures.

- Risk methodology: We developed practical methods for assessing risk with multivariate data. Measures of dependence have been devised which can guide understanding of concurrence of risks as well as test for various types of asymptotic or extremal independence. Alternatives to numerical summaries of dependence depend on estimating the support of the heavy tail limit measure and this estimation is based on a grid method suitable for high dimensional data. Several R-based packages are running; some of these are linked to the MURI website <https://www.orie.cornell.edu/research/research-groups/multivariate-heavy-tail-phenomena-modeling-and-diagnostics>.

- Assessing risks often depends on extreme value tail estimation methods. These methods requires a threshold selection beyond which the modeled tail is assumed to begin. We have investigated several approaches:
 - a. averaging over various thresholds to minimize information loss due to discarded observations;
 - b. automated procedures based on minimum distance minimization between fitted tails and empirical tails;
 - use of a robust tool called distance covariance.

Each method can be fooled but each offers guidance in appropriate circumstances.

- The importance of large dimensional data in finance, insurance and risk necessitated finding methods for dealing with heavy tailed dimension reduction

both from the point of view of parametric standard stable models and more general regularly varying models. Graphical methods and numerical summaries offer guidance about which vector components possess enough dependence to create systemic risk worries.

- Statistical methodology: We created extreme value methods for analyzing data when extremes are omitted from the sample. For example, this can occur when users mask their behavior or presence on a network. Despite the unknown quantity of missing data, tail descriptors are still required for prediction.

Distance covariance was further applied to the issue of testing goodness of fit of traditional time series models such as ARMA, ARCH, GARCH. The fact that much network data is count data which is discrete required research on extremes from discrete data; associated inference methods result in more accurate estimation methods than the currently used practice of ignoring the discrete nature of observations.

In the parametric class of multivariate stable laws, we developed a new method for parameter estimation based on fractional moments (since few or no integral moments exist). We developed related fitting methods for multivariate extreme value distributions using dense classes of models such as discrete spectral measures and generalized logistic. An accompanying R-package *mvevd* (linked through the MURI web site) now exists and can run simulations and evaluate methods.

- More Core theory: We now understand the joint behavior of Levy process jumps and the trimmed process with the jumps removed. This is part of a stream of work that provides robust estimation methods for continuous time risk models with jumps and relates to trimming in classical statistics. We now understand extreme behavior of random fields in important cases with important spinoffs to environmental modeling.

- Software: Nolan packages are updated and posted to the R-repository CRAN and linked to our MURI site. They give the ability to do various calculations with multivariate heavy tailed distributions. One can calculate multivariate stable probabilities, likelihoods and densities of ratios of stable random variables. Also on the MURI website are links to software for simulating preferential networks and fitting parameters.

[2B] Engineering and networks

- Network model calibration. Preferential attachment is an explanatory mechanism for describing social network growth. A series of papers gave methods for fitting a simple parametric growth model and three methods were given: a) MLE when a history with time stamps of edge creation is available; b) a single snapshot (SN) method when only the structure of the network is available at a single time point; (c) a robust extreme value (EV) method when one suspects data corruption or model error. Companion work developed simulation methods that allowed extensive experimentation to show the advantages and weaknesses of each method. The estimation techniques were tested on real data revealing how data needed to be cleaned and the methodology modified.

- Estimation for networks: Degree indices are typically estimated in CS and network science by a common method that is essentially standard *Hill estimation* from extreme value theory. This was adapted from the extremes literature where it was developed for repeatedly sampled data but not network degree data. We now know the estimator is consistent for tail indices for particular network growth models both in the directed and undirected cases. Asymptotic normality still eludes us but we have made significant progress justifying a widely used method.

- Network search: We developed search techniques that allow discovery of nodes with desirable characteristics within a graph. For example, this could be used to identify potential donors within a social network. The technique uses multi-armed bandit methods where arms correspond to different models of unknown nodes based on their known local neighborhoods.

- Graph classification: We created a graph neural network for the purpose of performing regression and classification tasks based on a quantum walk. Experiments indicate that quantum walks provide better models than classical random walks for small problem instances; however a limitation remains that computational effort increases substantially with heavier degree distributions.

- Network sampling. Multidimensional random walk sampling algorithms have been developed for the purpose of characterizing large directed graphs. These algorithms take advantage of the heavy-tail nature of the joint in- out-degree distribution to reduce sampling errors.

- Uncovering network structure: Big data efforts focussed on identifying the

core structure of the Google+ network serving as a practical test of proposed algorithms. This suggested general methods for uncovering the nucleus that supplement the k-shell method. Further work exposed weaknesses to standard graph capsule convolutional neural network methods and gave solutions.

- Power management. Ness Shroff and coworkers were awarded a patent for a highly energy efficient context aware scheduler on background applications in mobile systems. This complimented his work on minimizing latency time when launching apps in a mobile context as well as minimizing power usage when switching between wifi and 4G networks.

- Parallel or cloud computing: How do you reduce job latency across multiple servers for either parallel processing or cloud computing? The commonly used strategy of replication and task assignment across multiple servers induces dependence across servers, which makes it difficult to quantify the performance benefit of such strategies. However, replication/task assignment improves performance dramatically especially when the task service-time distributions have a large variance or are heavy-tailed provided the task delays in different servers are independent.

- Graph matching: The network deanonymization problem has the goal of inferring node identities in an anonymized graph by observing the node identities and topology of a dependent graph. Label the nodes of the anonymized graph so that the adjacency matrix of the anonymized graph matches the adjacency matrix of the correlated graph as closely as possible. Given certain connectivity and sparsity constraints, and assuming a noisy estimate of the true label matching, a proposed algorithm corrects errors provided the noisy estimate contains a certain number of correct matches. The algorithm works well on random graph models as well on publicly available real network datasets.

- Image recognition: Scaling phenomena in natural images suggest new feature vectors for scale invariant object recognition. Our approach develops relational information and retrieving methods.

- Networking: Age-of-Information and How to Keep Data Fresh. How do we balance freshness of data with network throughput, minimal delay for updates, and energy consumption in heterogeneous transmission environments where packet transmission times and job sizes could be heavy tailed? We devised alternatives to the zero-wait update policy in which the source node submits a fresh update once the previous update is

delivered and the channel becomes free which achieves the maximum throughput and the minimum delay. But the zero-wait policy does not always minimize age. This problem was specialized to mobile devices where application freshness is balanced with energy requirements, base station overloading and freshness in an environment where inter-launch times of an application are heavy tailed.